IMPROVEMENT OF URBAN GOODS MOVEMENT- ALEXANDRIA CASE STUDY-

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ABSTRACT

The planning goal of an efficient transportation system must include the objective of minimizing the inevitable conflicts between person and freight movement. Achievement of an efficient transportation product line depends not only on further research into the demand but more particularly on the supply capabilities of transportation systems and its distribution systems. This paper considers the problems of urban goods movement, Alexandria city as a case study, particularly those associated with the physical distribution of freight in urban areas, and focuses on an analysis of consolidation strategy and the impact of the number of consolidation points on various system performance elements. A location model is derived and applied to the case study. A computer program called "URBAN1" is developed for this purpose.

INTRODUCTION

Urban goods movement has not received much attention in urban transportation planning in Egypt. This lack of attention is due to the lack of control, understanding, and information for this sector, that makes it an unlikely candidate for systematic analysis. Data about urban goods movement are hard to find because the privately operated urban goods movement is highly diverse and fragmented.

Decentralization in freight distribution systems in the urban goods movement sector contributes urban congestions; noise, and visual pollution, and road surface deterioration. Thus, the urban goods movement system does not operate in the most efficient manner, whereby system capacity, fuel, and manpower, are used inefficiently. These deficiencies are detrimental in terms of higher transportation costs imposed on consumer products, and the externalities generated by the urban goods movement system.

Another principle problem in the urban goods movement is that freight systems in the urban goods movement community, seldom cooperate with each other. Although it is the best interest of them to coordinate their activities and to cooperate in a constructive framework of information and data exchange.

This paper contains three parts. In the first part, the sources of the urban goods movement problems will be identified. In the second part, the freight distribution strategies in Alexandria city, as well as a proposed consolidation strategy will be analyzed. In the third part, a location model will be derived, and applied to the case study. In addition, a computer program, which has been developed for this purpose, will be described.

The purpose of this paper is to search for an urban network design that would produce an efficient loading pattern with minimal truck congestion and lowest possible transport cost.

SOURCES OF URBAN GOODS MOVEMENT PROBLEMS

Metropolitan areas growing, and it follows growing in the urban goods movement causing congestion. Urban commodity flow can be viewed as the result of human activity that occurs within a defined space. To maintain that activity requires that materials be imported for consumption and processing and that manufactured goods be exported. In the process of importing and exporting commodities, an urban metabolism occurs.

The poor quality of roads in areas of heavy trucking and congestion on narrow roadways raised the estimated cost of congestion. For example, an independent analysis of the cost of congestion in the garment center in New York, prepared by the New York Trucking Association, estimates the annual cost of traffic congestion in midtown Manhattan at $ 150 million [4].

Older warehousing blocks are ill-equipped to efficiently handle the truck traffic and tonnage that flows daily into the urban area. Probably the greatest obstacles to efficient loading and unloading of goods are narrow street width and the absence of off-street loading docks. The fact that trucks and automobiles have to share the same streets causes several problems.The overall vehicle flow is impeded because of different driver eye heights and ranges of vision and the slower acceleration and the lack of maneuverability of trucks.

Absence of on-street loading/unloading facilities, poor geometric design of roadways, inadequate traffic operational strategies, lack of enforcement of loading zone restrictions, poor land use planning and control, lack of specialized equipment for freight handling and transportation, increase in the number of small shipments, dispersion of economic activity centers, and lack of efficient freight distribution system, are other sources for urban goods movement problems.

Transportation sources are the main contributors of air pollution in urban areas. A major source of air pollution are the trucks. In New York city, it is estimated that 70 % of all air pollution originates from transportation sources, where 60 % of vehicle-related pollution contribute from the trucks [12].

Although, it is difficult to quantify the effects of trucks on ambient noise levels, some data indicate that, whereas average noise levels on the busier city streets range from 70 to 75 dBA, trucks cause peaks of 88 to 97 dBA [4].

PROPOSED CONSOLIDATION STRATEGY

Two urban freight systems are used in the city of Alexandria:

- o urban freight movement to/from the port of Alexandria mainly with origin/destination outside the city, and
- o urban freight movement mainly with origin/destination inside the city

These systems are performed under two major distribution strategies (see Figure 1):

- o The first and most common strategy is field warehousing. Under this strategy, the firm maintains a network of warehouses in anticipation of market demands originating in the region surrounding the warehouse. This strategy is used mainly in the first urban freight system.
- o The second strategy is Less-Than-Truck-Load (LTL) strategy. Under this strategy, the firm ships each order directly to the customer without the need to warehousing. This strategy is used mainly for the second urban freight system.

The first urban freight system maintains the network of warehouses in urban areas near the port contributing heavy traffic congestion in these areas. The warehouses lead directly onto the urban roads without internal loading/unloading zones. The internal organization of the port itself, which is based on the direct connection between the piers and the exit, is another contributor for the heavy traffic congestion in port area. The interference between intercity and urban freight transport is another disadvantage of the first strategy.

The second distribution strategy is inefficient; trucks are lightly loaded travel too many kilometers, run at low speeds and operate during hours of the highest vehicular congestion. The results of this inefficiency are traffic congestion, increased energy consumption, air and noise pollution, broken and worn-out road pavements and high commodity cost.

The idea of introducing some sort of consolidation of goods movement may have a powerful appeal, much like that of mass transit. Consequently, most proposals for improvement of urban goods movement must contain som aspects of consolidation, such as, platform operations fo intercity LTL- shipments consolidated at a union terminal and delivery services in a given sector of the urban are performed by a single carrier.

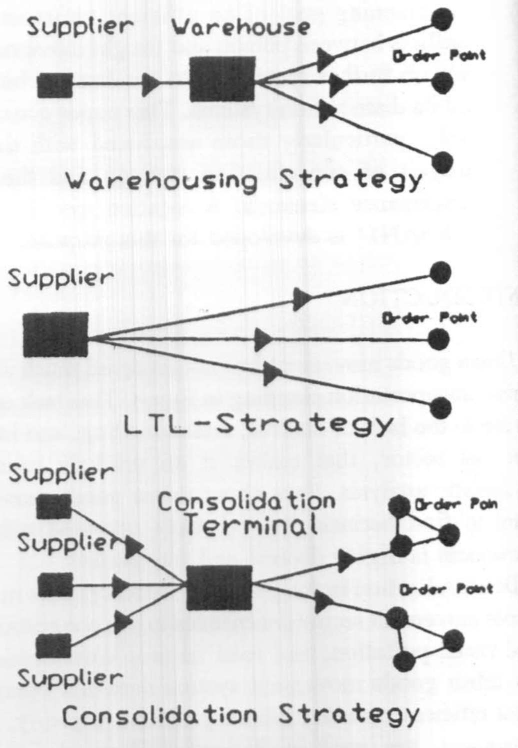

Figure 1. Freight distribution strategies.

Consolidation strategy is a freight distribution system th can reduce traffic congestion, and transport cost. Under th strategy, shippers can use freight consolidation termina which enables the system to build orders with truck lo shipments according to the geographical location of the ord points (see Figure 1).

LOCATION MODEL

The physical elements of a distribution network in a co solidation strategy are terminals, a set of routes betwe these terminals and the consignees serviced by the syste and vehicles that routinely transport the freight within t system.

Terminals are the main element in the distribution syst because their functions are directly related to the objecti of the actual distribution of freight. Terminals break do line-haul shipments between the primary producers and consignees, act as intermediate storage points to prov 'production smoothing" of the flow of goods to the consignees, and provide transferral and reassembly of freight from the incoming method of transportation to that of the outgoing method. Terminals act as a transfer point between intercity freight transport and urban goods movement. They combine several small LTL-orders into large truckload shipments according to the geographical location of the orders.

Factors affecting assignment of terminals to location in an urban network are the distance between destinations and terminals, the cost of transporting a unit material between the two locations, and the traffic intensity of routes between these locations.

The "distance" between destinations and terminals affect the total costs of the transported materials between the locations. The "traffic intensity" is the rate at which units of materials are transferred between terminals and destinations, or more generally, a measure of some dependence between the two locations.

Mathematical approaches to the optimal location of consolidation terminals are based on or related to the generalization of the problem of determining the location of a point, in two-dimensional space that represents the minimum distance or cost for a number of weighted destinations [3,6,8]. In this paper, a correction factor, which represents the traffic intensity of the connection routes, is derived and considered in a location model:

Given the location of each destination area $D_i(i=1,2,\ldots n)$ from consolidation terminal T as $r_i(i=1,2,\ldots n)$, the demand at each destination $a_i(i=1,2,\ldots n)$, the unit cost of one ton.km c, and the traffic intensity factor $b_i(i=1,2,\ldots n)$, determine (see Figure 2):

- o the number of consolidation terminals,
- o the location of each terminal, and
- o the capacity of each terminal

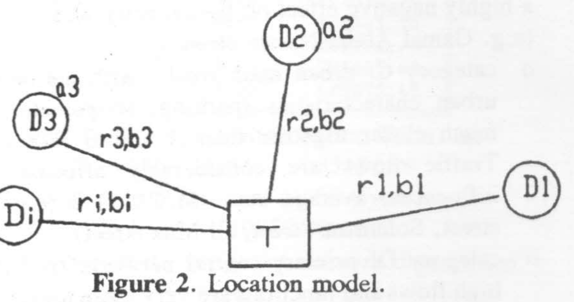

Figure 2. Location model.

The objective function of the location model can be expressed as:
the total transport costs,

$$F = c*a_1*b_1*r_1 + c*a_2*b_2*r_2 + \ldots + c*a_n*b_n*r_n$$

$$= c*a_i*b_i*r_i$$

$$F(x,y) = \sum_{i=1}^{n} * a_i * b_i * r_i \dashrightarrow \min \ldots \qquad (1)$$

$$r_i = \sqrt{(x-x_i)^2 + (y-y_i)^2}$$

where:

x,y: the required cartesian coordinates of the terminal

x_i,y_i: cartesian coordinates of the destination i to solve this model, by differentiation:

$$\frac{dF}{dx} = \sum_{i=1}^{n} \frac{C*a_i*b_i}{r_i} *(x-x_i) = 0$$

$$\frac{dF}{dy} = \sum_{i=1}^{n} \frac{C*a_i*b_i}{r_i} *(x-x_i) = 0 \qquad (2)$$

for (x,y) not equal (x_i,y_i), from (2):

$$x = \frac{\sum_{i=1}^{n} \frac{c*a_i*b_i}{r_i} *x_i}{\sum_{j=1}^{n} \frac{c*a_i b_i}{r_i}}, \quad y = \frac{\sum_{i=1}^{n} \frac{c*a_i*b_i}{r_i} *x_i}{\sum_{j=1}^{n} \frac{c*a_i b_i}{r_i}}$$

$$x^{(k+1} = \sum_{i=1}^{n} c*a_i b_i * \frac{\frac{x_i}{\sqrt{(x^k-x_i)^2+(y^k-y_i)^2}}}{\frac{c*a_i b_i}{\sum_{i=1}^{n}\sqrt{(x^k-x_j)^2+(y^k-y_i)^2}}} \qquad (3)$$

$$y^{(k+1} = \sum_{i=1}^{n} c*a_i b_i * \frac{\frac{x_i}{\sqrt{(x^k-x_i)^2+(y^k-y_i)^2}}}{\frac{c*a_i b_i}{\sum_{i=1}^{n}\sqrt{(x^k-x_j)^2+(y^k-y_i)^2}}} \qquad (4)$$

As a begin of the iteration, the center of gravity $(x^{(0)},y^{(0)})$ of the system must be determined:

$$x^{(0)} = \frac{\sum_{i=1}^{n} c*a_i b_i *x_i}{\sum_{i=1}^{n} x*a_i b_i}, \quad y^{(0)} = \frac{\sum_{i=1}^{n} c*a_i b_i *x_i}{\sum_{i=1}^{n} x*a_i b_i}$$

The capacity of the consolidation terminal can be expressed as:

$$k = a_i.$$

CASE STUDY

For applying the location model to the case study, Alexandria was divided into 13 market areas and a port region (Mina of Alexandria). For the port region, a special consolidation terminal would be assigned. The location model would be applied to the 13 market areas.

For this purpose, a computer program called "URBAN1", has been developed. It contains three modules (see Figure 3):

- o Input data module,
- o Forecasting module, and
- o Distribution network module.

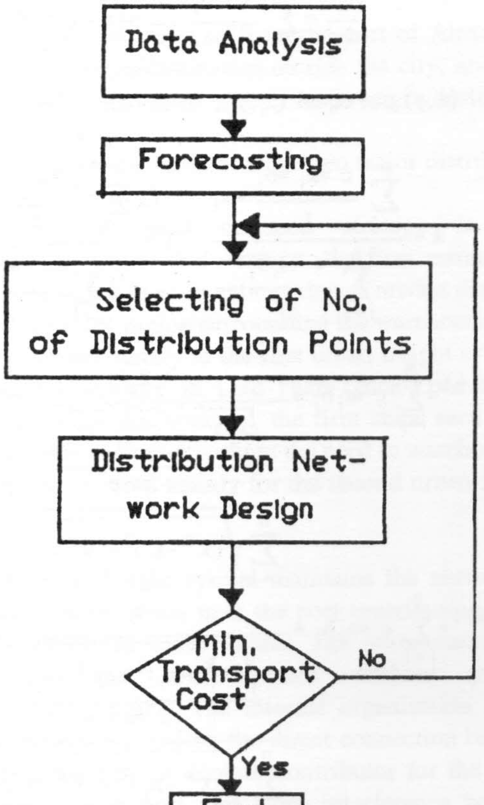

Figure 3. Urban goods movement modelling.

The first module serves for analysis of input data (population, employment, etc.), the second for forecasting the freight demand for the 13 market areas Alexandria's, and the third for optimizing the distribution network (number,location, and capacity of the required terminals and its order points).

Table 1 presents the two dimensional space (x_i,y_i), and the forecasted demand a_i (for the year 2020) for the 13 market areas. The forecasted demand was calculated according to the models in [1].

Traffic intensity factor b_i, was taken for the traffic condition in market area i according to the average r M/C of the main routes in this area, where "M" is the ac traffic volume and "C" is the capacity.

"M" was taken according to a traffic survey made in [To estimate the capacity of main routes of Alexandria ur road network, five basic categories of roads were identi [14]:

- o category A: urban highway - with junctions not at -gr or, where the flow characteristics are basically n influenced if the junctions are at - grade, relative go road surface, little or no lateral influence, average ra M/C < 0.8 (e.g. Corniche road).
- o category B: urban main road-with excessive lateral influences, widely spaced at-grade junctions (1 to 2 km).

Table 1. Dimensional space and forecasted demand of the 13 market areas Alexandria's.

i	Marketarea	x_i	y_i	a_i (1000 t/a)
1	Mina El-Basal	11.75	1.75	2032
2	Gomork	11.00	1.00	831
3	Laban	12.30	1.30	436
4	Karmoz	12.00	2.20	1335
5	Amria	4.00	2.30	754
6	Dekelah	8.90	2.00	658
7	Manshiya	11.80	0.80	256
8	Attarin	12.60	1.70	444
9	MoharamBek	12.80	2.30	2334
10	Bab Sharky	13.00	1.40	1384
11	Sidi Gaber	14.00	1.70	1084
12	Ramel	14.80	1.90	4164
13	Montazah	16.20	1.70	4124

Sometimes with high levels of conflicting flows which have a highly negative effect on the capacity, 0.8 > M/C < 1.0 (e.g. Gamal Abdel Nasser street).

- o category C: urban main road - with the most common urban characteristics (parking, shops, etc.), junctions much closer together than A and B (800 - 1000 m). Traffic flows are considerably affected by lateral influences, average ratio M/C> 1.0 (e.g. Port Said street, Soleiman Street, El-Max street).
- o category D: primary central network: traffic axes with high flows and junctions are very close together (100 m), traffic regulations favours maximum traffic flows, average ratio M/C> 1.0 (e.g. Horreya, Salah Salem, Mohafsah streets).
- o category E: secondary central network: characterised by junctions which are extremely close together (50 - 60 m).

The values of the calculated traffic intensity factor b_i are represented in Table 2.

Table 2. Traffic intensity factors.

i	Market area	b_i
1	Mina El-Basal	1.20
2	Gomork	1.10
3	Laban	1.25
4	Karmoz	1.00
5	Amria	0.70
6	Dekelah	0.80
7	Manshiya	1.30
8	Attarin	1.15
9	Moharam Bek	0.90
10	Bab Sharky	0.70
11	Sidi Gaber	0.80
12	Ramel	0.75
13	Montazah	0.80

Three distribution networks were selected using the location model for one, two, and three distribution points. The results of the computer system to find the location and the capacity of the consolidation terminal according to the minimum transport costs for a one - point system is shown in Figure (4).

ONE POINT NETWORK SYSTEM

k	X(k)	Y(k)	F(X(k),Y(k))
0	13.1517	1.8042	232205.30
1	13.0758	1.8283	33151.09
2	13.0508	1.8342	66224.14
3	13.0373	1.8374	99279.09
4	13.0285	1.8394	132325.80
5	13.0222	1.8410	165367.70
6	13.0173	1.8421	198406.40
7	13.0134	1.8431	231442.80
8	13.0102	1.8439	264477.60
9	13.0075	1.8446	297510.90
10	13.0051	1.8451	330543.30
11	13.0031	1.8456	363574.70
12	13.0013	1.8461	396605.40
13	13.9997	1.8465	429635.40

Optimal Location of Consolidation Term. in:
13.08 1.83 33151.09
Capacity of Terminal (1000 t/year):
19850.00

Figure 4. Results of one-point network distribution system.

This indicates that the optimal location of a consolidation terminal for a one - point system has a dimensional space of (x=13.08, y=1.83) and transport cost of F(X,Y) = 33151. This corresponds market area between Moharam Bek and Bab Sharky with a system capacity of 19.85 Mio. t/a.
For a two - point system Figure (5), the optimal location has a dimensional space in (x=11.49, y=1.65), and in (x=14.64,y=1.86) and transport cost of F(X,Y) = 23555. These correspond the market areas between Mina EL-Basal and Gomork, and Raml, with a system capacity of 6.046 and 13.804 Mio. t/a.

TWO POINTS NETWORK SYSTEM

LOCATION OF 1st TERMINAL k	X(k)	Y(k)	F(X(k),Y(k))
0	10.9185	1.7345	73181.25
1	11.4856	1.6535	10355.09
2	11.6099	1.7029	19072.37
3	11.6669	1.7321	27493.62
4	11.6998	1.7501	35782.07
5	11.7212	1.7620	43995.55
6	11.7361	1.7702	52161.41
7	11.7470	1.7762	60294.72

Optimal Location of 1st Consolidation Term. in:
11.49 1.65 10355.09

LOCATION OF 2nd TERMINAL k	X(k)	Y(k)	F(X(k),Y(k))
8	14.5113	1.8466	159048.10
9	14.6377	1.8630	13200.17
10	14.6874	1.8709	26138.56
11	14.7146	1.8759	38975.55
12	14.7318	1.8795	51757.23
13	14.7438	1.8822	64503.88
14	14.7525	1.8843	77226.38

Optimal Location of 2nd Consolidation Term. in:
14.64 1.86 13200.17

Distribution Points(X,Y)	Order Points	F(X(k),Y(k))	Capacity 1000 t/year
11.49 1.65	Mina el B. Gomrok Labban Karmoz Amria Dekehlah Manshiya	10355.09	6046.0
14.64 1.86	Attarine Moharam Bek Bab Sharky Sidi Gaber Raml Montazah	13200.17	13804.0

Figure 5. Results of two-points network distribution system.

For a three-point system Figure (6), the least total transport cost (F(x,y) = 31752) can be achieved by a combination of points (x=11.81,y=1.80), (x=9.04,y=1.79), and (x=14.73,y=1.87). These correspond market areas between Labban and Minaa El-Basal, Dekhelah, and Raml, as distribution points.
The number of consolidation points is proved to be a critical issue to the system performance Figure (7). For a two-Point

network system, a maximum reduction of 29% of the total annual transport costs can be achieved.

THREE POINTS NETWORK SYSTEM

LOCATION OF 1st TERMINAL			
k	X(k)	Y(k)	F(X(k),Y(k))
0	11.7633	1.7102	62198.83
1	11.8066	1.7958	2283.86
2	11.8015	1.8001	4318.09
3	11.8005	1.8001	6337.92
4	11.8002	1.8001	8355.47

Optimal Location of 1st Consolidation Term. in:
11.81 1.80 2283.86

LOCATION OF 2nd TERMINAL			
k	X(k)	Y(k)	F(X(k),Y(k))
5	9.0413	1.7923	17490.60
6	14.7785	1.8894	35226.57
7	14.7864	1.8926	46763.72
8	14.7909	1.8947	58280.32
9	8.9816	1.9649	22271.20

Optimal Location of 2nd Consolidation Term. in:
9.04 1.79 17490.60

LOCATION OF 3rd TERMINAL			
k	X(k)	Y(k)	F(X(k),Y(k))
10	14.6055	1.8539	95508.87
11	14.7265	1.8746	11979.27
12	14.7629	1.8841	23649.33
13	14.7785	1.8894	35226.57
14	14.7864	1.8926	46763.72
15	14.7909	1.8947	58280.32

Optimal Location of 3rd Consolidation Term. in:
14.73 1.87 11979.27

Distribution Points(X,Y)		Order Points	F(X(k),Y(k))	Capacity 1000 t/year
11.81	1.80	Mina el B. Gomorok Labban Karmoz	2283.86	4634.0
9.04	1.79	Amria Dekehlah Manshiya Attarine	17490.60	2112.0
14.73	1.87	Moharam Bek Bab Sharky Sidi Gaber Raml Montazah	11979.27	13104.0

Figure 6. Results of three-points network distribution system.

CONCLUSIONS

In order to minimize the inevitable conflicts between person and freight movements, urban goods movement must have more attention in urban transport planning in Egypt.

Deregulation of freight distribution in urban ar contributes a disproportionate amount to urban congestio noise, and visual pollution, and road surface deteriorati In such a way the urban goods movement does not opera in the most efficient manner, whereby system capacity, fu and manpower, are used inefficiently. These deficiencies a detrimental in terms of higher transportation costs impos on consumer products.

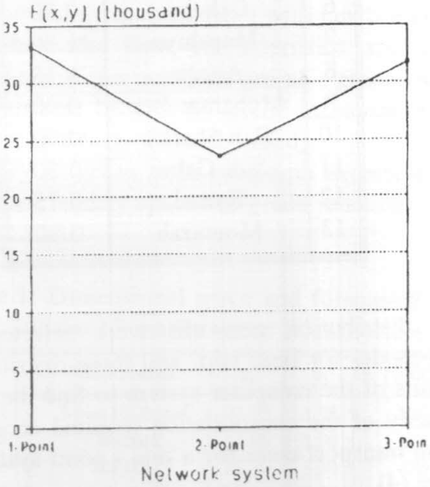

Figure 7. Selection of network distribution system.

Freight consolidation has been suggested as an effective way to reduce transportation costs, improve service levels for small shipments, and reduce on-street traffic an pedestrian conflicts. Furthermore, it produces an efficien loading pattern for an urban network with minimal truc congestion.

Terminals are the main element in a consolidation strategy They break down line-haul shipments between the primar producers and the consignees, act as intermediate storag points to provide "production smoothing" of the flow o goods to the consignees, and provide transferral an reassembly of freight from the incoming method o transportation to that of the outgoing method. They combin several small Less-Than-Truckload-orders into larg Truckload shipments according to the geographical locatio of the orders.

Distance between destinations and terminals, the cost o transporting a unit material between the two locations, an the traffic intensity of routes between these locations, proved to be important parameters for assignin consolidation terminals to a location in an urban network. Three distribution networks were discussed for Alexandr metropolitan area. The number of consolidation points proved to be a critical issue to the system performance. F a two-point network system, a maximum reduction of 29 of the total annual transport costs can be achieved.

Finally, achievement of an efficient freight distributi system depends also on its organization. This organization should set up the system for scheduling, coordinating, and operating the transportation system and would control all truck movements.

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